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Macular function surveillance revisited

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Abstract

BACKGROUND: The Amsler grid is a widely used means of evaluating the central 20° diameter visual field. It is a common practice to have patients who are at risk for exudative maculopathy evaluate their macular function daily using the Amsler grid. The goal is to make the patient aware of the earliest symptoms of choroidal neovascularization at a time when therapeutic intervention has the greatest chance for success. There are, however, several important shortcomings of self-monitoring macular function with the Amsler grid, including low sensitivity and low compliance.

METHODS: The history of macular function surveillance is reviewed. The following techniques that are either currently available or under development for home self-monitoring of macular function are discussed: Amsler grid, red Amsler grid, threshold Amsler grid, environmental Amsler techniques, entoptic perimetry, preferential hyperacuity perimetry, and Internet-based interventions.

CONCLUSION: There is compelling evidence that several currently available technologies are superior to the conventional Amsler grid in detecting the earliest symptoms of macular disease. Threshold Amsler grid, entoptic perimetry, and preferential hyperacuity perimetry each have been found to be more sensitive than the conventional Amsler grid in detecting vision disturbances caused by macular disease. Any one of these diagnostic tests could conceivably be utilized by patients at home for self-monitoring of macular function if the technology were suitably deployed for this purpose, such as over the Internet.

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Early recognition of the symptoms associated with choroidal neovascularization is clinically beneficial because the timely treatment of vision-threatening macular disease can minimize permanent vision loss.[1-6] Patients who are identified as being at risk for the development of choroidal neovascularization are advised to self-monitor their vision for symptoms that may signal the onset of such a lesion.[7-9] It is believed that by monitoring vision on a daily basis, patients may be better able to recognize the earliest symptoms of a lesion and thereby present for treatment when there is the greatest chance for preservation of vision. This report reviews the history and current developments in the field of patient self-monitoring of macular function.

The history of macular function surveillance

The use of grids to document symptoms of macular disease dates back to 1862, when Richard Förster published the first medical illustration of metamorphopsia.[10] However, it was not until the publication of a series of grids by Marc Amsler in 1953 that macular grid testing gained widespread popularity.[10,11] The development of effective therapies for retinal disease, principally ophthalmic lasers in the 1960s, led to a need for detecting symptoms of potentially treatable macu-

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lar lesions. It is believed that Schlaegel et al.[12] were the first to advise patients at risk for choroidal neovascularization to monitor their vision at home with an Amsler grid. The landmark Macular Photocoagulation Study utilized daily central field evaluation of the treated eye with the Amsler grid as a means to facilitate early detection and examination of patients with neovascularization secondary to age-related macular degeneration (AMD), ocular histoplasmosis, and idiopathic neovascularization.[3-5] They reported success in encouraging patients to check the central visual field daily with an Amsler grid.[8] In 1983, Fine[7] recommended that patients with drusen or atrophic changes in the macula be instructed to check their vision daily with an Amsler grid and to immediately report any changes that they perceived. Monitoring of the central visual field has since been found to be beneficial for patients with a variety of other ocular diseases, including diabetic retinopathy[13] and cytomegalovirus retinitis.[14]

Questions have been raised regarding the reliability of the Amsler grid in detecting central field defects in patients with macular disease.[9,15,16] In 1986, Fine et al.[9] reported that noncompliance was the largest factor responsible for the failure of patients with neovascular membranes to detect visual symptoms. Only 49 of 89 patients (55%) who were issued an Amsler grid for self-testing were actually using it to monitor their vision on a regular basis. They recommended that patients be instructed to monitor their vision in a variety of ways, including Amsler grid, reading ability, image clarity, color intensity, and absence of distortion of straight edges and lines in the environment, such as telephone poles and electric wires. Schuchard[15] compared standard and threshold Amsler grid testing with standard and threshold fundus perimetry in 55 patients with macular disease and 10 normal controls. (Fundus perimetry, also known as microperimetry, is a psychophysical test of retinal sensitivity. It is performed by stimulating specific regions of the retina with a stimulus of known size and luminosity eliciting a response from the individual if the stimulus is perceived.[17]) Schuchard found that nearly half of the scotomas discovered with fundus perimetry were not detected with Amsler grid testing. He concluded that the perceptual filling in of the grid pattern across scotomas and eccentric fixation was a major factor that prevented the accurate interpretation of Amsler grid findings in the clinical diagnosis of retinal lesions. In a retrospective review of their Amsler chart self-monitoring protocol, Zaidi et al.[16] found that their protocol detected less than 30% of AMD patients placed on home monitoring who subsequently had choroidal neovascularization. Younger patients were more likely to detect their symptoms with the Amsler chart than older patients, but this trend did not reach statistical significance. They concluded that Amsler grid surveillance of macular function was suboptimal and called for a new screening protocol used modern technology. Others have joined the call for making the development of a cost-effective self-assessment tool for patients with macular degeneration a research priority.[18]

As progress in the treatment of macular disease continues, the shortcomings of Amsler grid surveillance have come under renewed scrutiny. A number of potential alternatives to the Amsler grid are now available. We review the currently available options and emerging technologies for macular function surveillance.

Amsler grid techniques

Conventional Amsler grid

The series of 7 macular charts that are currently in widespread clinical use to test macular integrity were originally published by Marc Amsler in 1947.[19] Known today as the Amsler grid, the test evaluates the central 20° diameter visual field. The standard test chart is a white grid on a black background composed of 5-mm squares, which, when viewed at 30 cm, each subtend a 1° visual angle (*see* Figure 1). There are conflicting reports regarding whether the original design (white grid on a black background) is superior to a black grid on a white background.[20,21]

Since first introduced, the Amsler test has become a very popular means of evaluating the central visual field. Advantages of the test are that it is of low cost, rapid to perform, easy to explain and understand, and has the ability to detect both scotomas and metamorphopsia. The Amsler grid is very well suited to macular function surveillance by patients at home. This has led many retinal authorities to recommend that the Amsler grid be used for this purpose. The American Academy of Ophthalmology, as an example, has assigned the highest level of importance to the recommendation that patients with intermediate-stage AMD be educated about detecting new symptoms of choroidal neovascularization using the Amsler grid or reading vision.[22]

However, as previously discussed, there are several important disadvantages that limit the effectiveness of macular function surveillance with the Amsler grid, chiefly low sensitivity and poor compliance. Attempts to improve the sensitivity and the Amsler grid have included modifying its color and contrast and are discussed in detail later. Poor compliance is a more challenging problem to overcome. Table 1 lists some strategies that may improve patient compliance with macular function surveillance.

Red Amsler grid

All Amsler grids are suprathreshold tests of the central visual field. Any suprathreshold visual field test may fail to detect subtle relative scotomas because the stimulus (in this case the lines of the grid) is powerful enough to elicit a response even within the region of reduced sensitivity of the scotoma. When the Amsler grid test is performed on patients who are likely to have relative scotomas (such as patients taking hydroxychloroquine[23,24]), a red grid on a black background has been used in an attempt to decrease

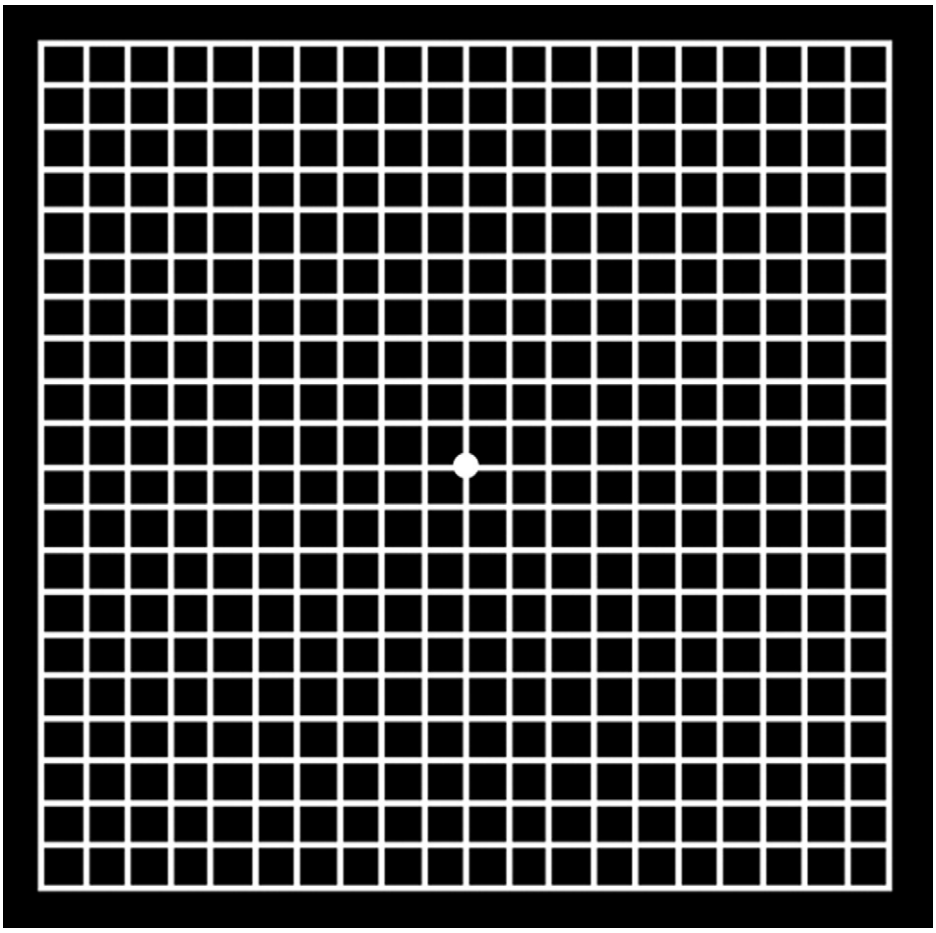

Figure 1 The Amsler grid.

the intensity of the stimulus. Use of the red Amsler grid has been reported to increase the detection of scotomas when compared with the standard Amsler grid.[23,24] A consequence of increased sensitivity may be a higher rate of false-positive responses. A recent study looking at this question found that 6% to 11% of all patients screened with a red Amsler grid in an outpatient rheumatology setting had a false-positive result.[25] False-positives are rare with the standard Amsler grid.[15]

Threshold Amsler grid

Another approach designed to increase the sensitivity of the Amsler grid is to view the grid through cross polarizing lenses that decrease the luminance of the grid until it is barely perceptible. Under such conditions, the test detects more scotomas, and the area covered by these defects is greater.[26] Almony et al.[24] reported good success using the threshold Amsler grid to detect maculopathy in asymptomatic patients taking hydroxychloroquine. Schuchard[15] found the scotoma yield to be higher with the threshold Amsler than with the standard Amsler test; however, there was little difference in the sensitivity of the 2 systems when compared with the gold standard of fundus perimetry performed with the scanning laser ophthalmoscope.

An alternative to using cross-polarizing lenses to decrease the visibility of the Amsler grid is to use low-contrast charts. Cheng and Vingrys[27] found that low-contrast (18%)

Table 1 Strategies to improve compliance with macular function surveillance

1. Instruct patients to monocularly assess vision in a variety of ways, including Amsler grid, reading vision, inspection of straight edges in their surroundings, and entoptic perimetry with a home television. Reinforce compliance at each office visit.
2. Educate family members on macular surveillance protocols so they may reinforce patient compliance.
3. Motivate patients to comply by educating them about available treatments for choroidal neovascularization.
4. Follow-up in-office education with phone or mail contacts.
5. Take steps to improve the doctor–patient relationship to improve communication and establish trust and mutual cooperation.
6. Refer patients to a macular degeneration support group.
7. Refer noncompliant patients to compliance therapy or mood and behavioral management performed by a behavioral (medicine) specialist.

Amsler grid charts were significantly more sensitive than high-contrast (90%) charts. They also report that low-contrast charts are superior to cross-polarizing lenses because, unlike cross-polarizing lenses, low-contrast charts do not affect luminance and adaptation levels that have the potential to confound performance on the test.

Recently, the threshold Amsler grid test has been computerized, such that the contrast is varied on a computer monitor rather than with cross-polarizing lenses.[28,29] Patients are instructed to outline their scotomas on a touch-sensitive computer monitor at varying contrast levels. The results are then analyzed to produce a 3-dimensional depiction of the scotoma. Using this device, patients with nonexudative AMD were found to have scotomas with steep sloping margins, whereas patients with the exudative form of the disease were found to have scotomas with shallow sloping margins.[29] The investigators concluded that this device is an effective tool for accurately evaluating, characterizing, and monitoring scotomas in patients with AMD.[29]

Nongrid techniques

Although the Amsler grid has been a mainstay of macular function evaluation since its inception, a number of alternative techniques have been developed to improve the ability to assess the central visual field and detect the earliest symptoms of macular disease.

Environmental Amsler

Unfortunately, few patients who are instructed to monitor their vision on a daily basis with an Amsler grid will actually do so.[9] Therefore, patients should always be advised to monocularly assess their vision in multiple ways, referred to as environmental Amsler techniques. These functional vision tests include checking reading ability, straight edges for signs of distortion, overall image clarity, and color intensity (*see* Table 2).

It has been reported that patients with choroidal neovascularization are more likely to recognize changes in their near vision than vision at distance.[9] Therefore, patients should be especially encouraged to evaluate the clarity of their vision while engaged in near tasks, such as reading.

Entoptic perimetry

Noise field campimetry is a means of making scotomas visible that are not normally perceived by patients because of perceptual filling in.[30,31] It is performed by having the patient view a video display that is filled with small black and white spots flickering randomly at high frequency. A normal observer will report that the field is completely filled with random visual noise patterns, often described as "snow" or "static." Patients with acquired prechiasmal visual field defects may perceive that defect as a region that can variously appear motionless, dark, grey, or otherwise different from the remainder of the video display. Entoptic perimetry is then performed by having the patient trace the outline of the scotoma. This technique has been used successfully in studies to screen patients for glaucoma[32] and a variety of retinal disorders, including AMD,[33] diabetic retinopathy,[34,35] and cytomegalovirus retinitis.[36] These studies report excellent sensitivity and specificity data. Brown reported that entoptic perimetry is 89% more sensitive than Amsler grid in detecting clinically significant macular edema in diabetic patients.[35] There are, to our knowledge, no published reports directly comparing entoptic perimetry with Amsler grid in patients with AMD.

The static produced by a conventional television tuned to a nontransmitting station is effective for performing entoptic perimetry.[32,35,37] Therefore, this technique is a viable method of macular function surveillance for any patient with access to a television at home (*see* Table 3).

Preferential hyperacuity perimeter

Hyperacuity, also known as Vernier acuity, refers to the ability to judge whether a pair of target features is aligned.[38] The preferential hyperacuity perimeter (PHP) presents the subject with a dotted line on a computer screen with 1 dot out of alignment with the others. The subject, fixating a

Table 2 Patient instructions for environmental Amsler

1. Wear the appropriate eyeglasses for distance or near vision.
2. Cover or close one eye.
3. Inspect a familiar straight object or pattern of straight lines in your surroundings for signs of waviness. Common examples include:
   - Door frames
   - Telephone poles
   - Ceiling or floor tiles
   - Crossword puzzles
   - Lines of text on a page
4. Repeat procedure with the other eye.
5. Make it a habit to check the straightness of lines that you encounter in your surroundings on a daily basis. Become familiar with differences in clarity of vision between the 2 eyes.
6. Immediately report any changes that are observed to your eye doctor.

Table 3 Patient instructions for entoptic perimetry using a television

1. Tune the television to a station without a signal such that the screen is full of static.
2. Sit directly in front of the television screen and as close to it as possible. Your eyes should be no more than 2 to 3 feet from the screen (sit closer to sets with smaller screens) and as close to level with it as possible.
3. You do not need to wear eyeglasses unless instructed to do so by your eye doctor (note: vision correction is not required unless uncorrected near acuity is less than 20/200).
4. Stare at the center of the television screen with one eye closed or covered for 5 seconds, then switch eyes. Stare at the center of the screen for 5 seconds with the second eye.
5. Repeat the above procedure until each eye has looked at the television screen at least 3 times, or until you see a defect on the screen. A defect will appear as a region of the screen that is grey and motionless, or different in some other way from the rest of the screen. Note the position and size of any defects that you see.
6. Immediately report any changes that are observed to your eye doctor.

central point, touches the screen with a stylus at the perceived location of the misaligned dot. This procedure is repeated until the entire macular area is tested.[39]

The PHP has been shown to be more sensitive than the Amsler grid in detecting visual changes associated with AMD.[39-41] In one study, the increased sensitivity came at a cost of less specificity; the PHP had a higher rate of false-positive results than the Amsler grid.[39] Another study that used a modified software algorithm[42] reported better specificity, such that the PHP was able to successfully differentiate patients with intermediate stage AMD from those with neovascular lesions.[40] Kampmeier et al.[43] found that the relative sensitivity of Amsler grid and PHP in patients with AMD varied with the stage of the disease, with PHP being superior to Amsler grid only in those patients with geographic atrophy and choroidal neovascularization. Klatt et al.[44] reported that PHP is more sensitive than Amsler grid in detecting metamorphopsia caused by AMD with occult neovascularization but that the Amsler grid is superior in detecting metamorphopsia caused by macular hole, epiretinal membrane, and central serous chorioretinopathy. The utility of the PHP as a device for self-monitoring at home is reported to be under investigation.[39,41]

Internet-based interventions

The Internet holds promise as a cost-effective means to screen for vision problems. Many vision screening tests, including acuity, color vision, and perimetry, are currently available online.[45] The Amsler grid is widely available for download on numerous consumer-oriented health care Web sites. Internet-based macular function tests, such as MyVisionTest (Evansville, Indiana)[46] and Macustat (Peristat Group, Inc., San Francisco, California),[47] are still in their infancy. To our knowledge, sensitivity and specificity data for these online tests of macular function have yet to be published in peer-reviewed literature.

The Internet is well-suited to deliver self-care interventions for chronic illnesses, often referred to as e-health interventions.[48] Studies have found that Internet-based interventions are associated with improved behavioral outcomes compared with non–Internet-based interventions.[49] It would appear that the technologies used in computerized threshold Amsler grid, entoptic perimetry, and PHP would be well-suited to Internet delivery. There are significant challenges that face anyone attempting to design a Web-based vision test.[45] Nonetheless, as growing numbers of seniors avail themselves of personal computers and the Internet[50] the potential value of a validated online test of macular function grows ever larger.

Conclusions

The outcomes of treatment of choroidal neovascularization are generally better if the treatment is instituted earlier in the course of the disease. Since its introduction, the Amsler grid has been the cornerstone of macular function self-testing, but computer technology offers the hope of improved tests that may be suitable for home use on a personal computer. Computer-based technologies, as potential alternatives, offer the prospect of more sensitive tests that could enable patients to present for care sooner in the event of disease progression. Should the tests be designed with the AMD patient in mind, such that they are easy to use for older individuals with impaired vision, improved compliance is also possible. Poor compliance is the Achilles' heel of any macular function surveillance protocol. The clinician who prescribes home surveillance must continually review and reinforce compliance.

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